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(54) **Clamp connection to connect two structural elements, in particular, for an osteosynthetic fixation arrangement**

(57) A clamp connection (10) serves to connect two structural elements (12, 14), in particular for an osteosynthetic fixation arrangement. It consists of one connecting element (15), two clamp elements (18), as well as two bracing means (16, 16') associated therewith, in addition to which in each case a structural element is provided, transversely arranged and solidly clampable between the connecting element (15) and the clamp element (18). Opposite it, the clamp element (18) is in contact with the connecting element (15) parallel to the bracing direction and it is pressed by means of the moment generated by the bracing force against the connecting element with a bearing force acting perpendicular to the bracing force, which causes a frictional force between the clamp element (18) and connecting element (15), which as a single force reduces the bracing force on the structural element (12). A threaded screw (16) coaxial with the connecting element (15) and a nut (16') coming into contact with the clamp element (18) are provided for each of the two bracing means. With this clamp connection (10), a maximum possible resultant clamping force on the structural elements (12) is obtained and, in addition, its elastic design effects well-maintained bracing even after a relatively long period of time.

The invention concerns a clamp connection to connect two structural elements, in particular for an osteosynthetic fixation arrangement according to the generic portion of claim 1.

In a known clamp connection of the type mentioned in the introduction (DE-GM [German Utility Model] 91 01 321), two virtually identical clamp elements and a thrust washer positioned between them are provided, which are all penetrated as a unit by a centrally arranged threaded screw of the bracing means. The latter rests on the upper clamp element and is screwed into the lower clamp element. The clamp elements have two semicylindrical recesses each that serve to accommodate structural elements designed as rods. With this clamp connection, two such structural elements can be fixedly connected to each other, in that a rod, for example, a carbon fiber rod, and a Schanz screw, are respectively inserted between one clamp element and the thrust washer, and are fixedly clamped by the threaded screw which has a rotary knob. The effective clamping force acting on the rod depends on the ratio of the distance between the axis of the bracing means and that of the rod to the distance between the axis of the bracing means and the seating of the clamp element of the thrust washer. In order to obtain the greatest effective clamping force on the rod with a given bracing force, the aforementioned ratio must be selected as small as possible according to the law of the lever. The result is that the clamp elements inevitably become larger in their dimensions. These clamp connections used in particular for external fixation in the applicational area of osteosynthesis are used principally for the fixation of relatively small body parts, whereby the clamp elements must not be dimensioned too large. In practice, it has been demonstrated that for the reasons mentioned, an inadequately solid clamping force and, consequently, no secure bracing between the structural elements or the entire fixation arrangement are obtained. Moreover, it often develops that the clamping force relaxes after a certain time and, thus, a fixation no longer actually exists.

In a clamp arrangement according to WO-A1 88/01152, clamping washers are provided analogous to the above-described prior art clamp connection, which washers, in each case in pairs, position a screw or the like in semicircular recesses and fixedly clamp it by means of a screw axially associated therewith. Two pairs of such clamping washers are provided for one bracing screw to connect two structural elements. This clamping arrangement has, in principle, the same disadvantages as that described above because the clamping force effectively acting on a rod is based precisely on an unfavorable ratio of the distance between the axis of the bracing screw and the seating of the clamping washers. Nothing about this is changed by the design of the clamping washers on the seating with the toothed engagement provided on both sides. In this known open system, the inclined planes present are not used to improve the clamping, but only to improve the centering between the connecting and the clamping element.

To remedy these disadvantages, the object of the present invention is to provide a clamp connection of the type described in the introduction, whereby with simple manipulation, a clamping force of the structural elements to be connected that is adequately strong and virtually constantly effective over a relatively long period of time is generated.

The invention accomplishes this object with a clamp connection which has the characterizing features of claim 1.

Such a clamp connection according to the invention has, in particular, the advantages that with it, with dimensions and with bracing force identical to those of the prior art, a significantly higher resultant clamping force is obtained. Moreover, this clamp connection is very elastic in its design, as a result of which the clamp connection does not loosen by itself with vibrations or the like and, consequently, the long-term effect of the bracing is maintained.

To obtain a maximum clamping force acting on the structural element, the ratio of the distance between the axis of the structural element and that of the bracing means to the distance between the central axis of the structural element and the line of action of the bearing force should be less than 1.0, and preferably between 0.6 and 0.1.

The bracing surfaces of the connecting and structural element, with respect to the bearing surfaces of the clamping and connecting element, are provided as smooth as possible in their surface characteristics for the purpose of mutual virtually friction-free support.

The connecting element may be designed cylindrical, cuboid, or in another shape and has on each of its faces an equiaxial threaded screw, whereby, on the latter, in each case a cap-shaped clamp element is arranged that exerts a clamping force on the structural element clamped between and contacts the bearing surface of the connecting element with its bearing surface parallel to the bracing direction.

The invention as well as additional advantages thereof are explained in detail in the following exemplary embodiments with reference to the drawings. They depict:

Fig. 1 a partial longitudinal section through a clamp connection according to the invention;

Fig. 2 a cross-section II-II according to Fig. 1;

Fig. 3 a longitudinal section of a clamp connection with a pedicle screw;

Fig. 4 a longitudinal section of another variant of a partially depicted clamp connection according to the invention;

Fig. 5 and Fig. 6 in each case, a perspective view of a variant of a clamp connection; and

Fig. 7a and 7b a longitudinal section through another variant of a partially depicted clamp connection according to the invention.

Fig. 1 depicts a clamp connection 10 as a component of a fixation arrangement (not shown in detail), which fixes two structural elements 12 and 14 to each other. These are, for example, a connecting rod, on the one hand, and a Schanz screw, on the other, which

is, for example, screwed into a fragment of a broken finger bone. A second clamp connection can then fixedly connect such a screw similarly in the other bone fragment with the aforementioned connecting rod.

The clamp connection 10 consists of a connecting element 15, of bracing means 16, 16' provided on both sides thereof, as well as of two cap-shaped clamp elements 18. The bracing means are made up in each case of a threaded screw 16 provided coaxially to the connecting element 15 and of a nut 16' moving the clamp element 18. In addition to the respective bracing means 16, 16', a structural element 12 arranged at a right angle thereto is clamped between the connecting element 15 and the clamp element 18, whereby the structural element 12 as well as the gripping surfaces 15' or 18', respectively, coming into contact therewith have as smooth a surface as possible, so that unwanted frictional forces do not appear.

According to the invention, the clamp element 18 rests against the connecting element 15 parallel to the bracing direction and it is pressed by the moment generated by the bracing force Fv against the connecting element 15 with a bearing force Fa acting perpendicular to the bracing force Fv, which causes a frictional force Fr between the clamp element and connecting element, which as a single force reduces the bracing force Fv on the respective structural element 12. In contrast to the direct support in the arrangement according to the prior art, the frictional force Fr in the present invention is, on the one hand, smaller by the factor of the coefficient of friction; on the other hand, the ratio of the distance a between the axis of the structural element 12 and that of the bracing means 16 to the distance b between the axis of the structural element 12 and the line of action of the bearing force Fa is smaller than 1.0, and preferably between 0.6 and 0.1. This can be achieved without having to enlarge the diameter of the clamp element and with it the entire clamp connection 10.

According to Fig. 2, the cylindrical clamp element 18 surrounds, on the one hand, the structural element 12 and, on the other, the connecting element 15. The threaded screw 16 in the center of the connecting element 15 further has a transverse groove 19, into which the structural element 12 projects. This results in a reduction of the dimensions of the clamp connection 10. The clamp element and the connecting element could also be designed rectangular or another shape in cross-section.

Fig. 3 depicts a clamp connection 20, which consists of a cylindrical connecting element 25 with a pedicle screw 23, of two annular clamp elements 28, 29 guided axially movable thereon, as well as of a bracing means 26, 26'. The latter, has, in turn, a threaded screw 26 associated with the connecting element 25, as well as a nut 26' screwed thereon, which comes into contact with the upper clamp element 28. The clamp element 28 presses, when tightened, against a structural element 22 designed as a transverse rod, which, in turn, presses against the second clamp element 29 and presses it against a structural element 24, that is supported on the connecting element 25 and is located like the other in a groove-shaped recess 25' thereof. The two recesses 25' are arranged one over the other and offset relative to each other at an angle of 90°, and at least one of them is designed such that the transverse rod positioned therein can be adjusted by a few angular degrees,

e.g., 40°, relative to the connecting element 25. The pedicle screw 23 positioned coaxially on the connecting element 25 is screwed into a bone or the like, while the transverse rod (structural element 22) and the other structural element 24 (longitudinal member) are connected to other clamp connections as components of a fixation arrangement. The surfaces 28', 25" of the connecting element 25 and of the bracing element 28 are rotationally symmetric and are designed in the contact zone, preferably in the form of a tooth construction, such that they can move against each other virtually free of friction in the bracing direction but cannot rotate. The position of the structural element 22 relative to the connecting element 25 is determined by a non-rotatable design of the inside surface of the clamp element 28 and the outside surface of the connecting element 25, preferably by longitudinal teeth or by a noncircular cylindrical geometry of the connecting element 25 and of the clamp element 28, preferably in a polygonal (e.g., hexagonal) shape.

A clamp connection 30 according to Fig. 4 includes two clamp elements 38, 39 and a substantially cylindrical connecting element 35 with screws 36 on both sides coaxial thereto provided as bracing means as well as recesses 35', 35" to support one structural element 12, 14 each. The first side recess 35" is designed such that, by means of its virtually semicircular shape, it effects three-point support in the braced state of the structural element 22. Advantageously, this latter is designed in tubular form such that for the purpose of increasing the clamping effect, it undergoes a certain deformation and adaptation to the recess 35". The other structural element 14 is pressed against by a clamp element 39 forming a longitudinal groove in an almost right-angled recess 35' of the connecting element. This latter as well as the connecting element 35 are oppositely prevented from rotating against each other by means of a circular cylindrical oblique tooth construction 32, but are arranged in contact with each other as free of friction as possible in the bracing direction.

Fig. 5 again depicts a clamp connection 40 to connect, in particular a Schanz screw 12 with a transverse rod 14 for an external fixation. In contrast to that according to Fig. 1, only one bracing means 46, 46' is provided for both rods to be clamped. A nut 46' is in contact with an upper clamp element 47 that has an oblong recess for the screw 42. The screw 42, for its part, rests on an intermediate ring 48 seated on the lower clamp element 49. This latter ring effects a bracing force on the clamp element 49, which clamps the transverse rod 44 against the connecting element 45. The two clamp elements 47 and 49 rest against the rods parallel to the bracing direction on the connecting element 45 by means of which the frictional force mentioned is generated as a reduced counterforce upon clamping.

The clamp connection 50 according to Fig. 6 differs from that according to Fig. 3 only in that the connecting element 55 has a single transverse recess 55' for a structural element 12. Otherwise, again by means of a bracing means 56, 56', a bracing force can be exerted via the clamp element 50 on the structural element 12 and a clamping thereof can be effected. In addition, the cylindrical connecting element 55 has a coaxial pedicle screw 24.

The clamp connection 16 according to Fig. 7a and 7b includes a substantially cylindrical connecting element 65 with a pedicle screw 63 and with a cylindrical recess 65', in which a coaxial threaded screw 66 is arranged and on it an outer cylindrical clamp element 68 fitting in the recess 65' is adjustably arranged by means of a nut 66' moving it. A structural element 12 provided on the side and at a right angle to the axis of the threaded screw 66, which element is arranged in an off-center slit of the connecting element 65, is clamped by the bracing force generated by the bracing means 66, 66' against the clamp element 68 against an inner bearing surface 65" of the connecting element 65. Opposite it, the clamp element 68 according to the invention lies on the connecting element 65 parallel to the bracing direction, whereby the maximum possible effective clamping force sought is in turn obtained on the structural element 12. In this embodiment, the recess 65' and the inner bearing surface 65" can be formed in two different types. In Fig. 7a, the elements 65' and 65" correspond to the shape of the structural element 12; in Fig. 7b, they are designed such that they effect a three-point contact along with the clamp element 68.

Naturally, the invention can have still other variants. It should merely be noted incidentally that, in principle, a different known principle could be used as the bracing means instead of a screw/nut connection.

Claims

1. Clamp connection to connect to structural elements, in particular for an osteosynthetic fixation arrangement, consisting of a connecting element, at least one clamp element and bracing means associated therewith, in addition to which a fixedly clampable structural element transversely arranged, between the connecting element and the clamp element, while opposite it, the clamp element is in contact with the connecting element, characterized in that the clamp element (18, 28, 29, 38, 48, 49, 58) is in contact with the connecting element (15, 25, 35, 45, 55) parallel to the bracing direction and it is pressed by means of the moment generated by the bracing force (Fv) against the connecting element (15, 25, 35, 45, 55) with a bearing force (Fa) acting perpendicular to the bracing force (Fv), which effects a frictional force (Fr) between the clamp element and connecting element which as a single force reduces the bracing force (Fv) on the structural element (12, 14, 22, 24).

2. Clamp connection according to claim 1, characterized in that to obtain as great a clamping force (Fk) as possible acting on the structural element (12, 14, 22, 24), the ratio of the distance (a) between the axis of the structural element (12, 14, 22, 24) and that of the bracing means (16, 16', 26, 26') to the distance (b) between the axis of the structural element (12, 14, 22, 24) and the line of action of the bearing force (Fa) is less than 1, whereby (b) is preferably greater than one-half the diameter (height) of the structural element.

3. Clamp connection according to claim 1 or 2, characterized in that the surfaces (18', 15') of the connecting element (15) and clamp element (18) are smooth for the purpose of virtually friction-free mutual sliding.

4. Clamp connection according to claim 1 or 2, characterized in that the surfaces (28', 25", 32) of the connecting element (25, 35) and the clamp element (28, 39) are rotationally symmetric and are preferably designed in the contact zone in the form of a tooth construction such that they are movable against each other virtually friction-free in the bracing direction but are not rotatable.

5. Clamp connection according to claims 1 through 4, characterized in that the connecting element (15) is designed cylindrical, cuboid, or with another shape and has on each of its faces an equiaxial threaded screw (16), on which a cap-shaped clamp element (18) is in each case arranged, which exerts a clamping force (Fk) on the structural element (12, 14) clamped between and opposite it rests against the bearing surface of the connecting element (15) with its bearing surface (17) parallel to the bracing direction.

6. Clamp connection according to claim 5, characterized in that the bearing surfaces (17) of the clamp element (18) and of the connecting element (15) are designed cylindrical, flat, or with another shape.

7. Clamp connection according to one of the preceding claims, characterized in that the connecting element (35) has a lateral recess (35"), which has a virtually semicircular

shape, which effects, together with the clamp element (38), a three-point contact in the braced state of the structural element (22).

8. Clamp connection according to claim 7, characterized in that the structural element (12) is advantageously designed tubular, so that, for the purpose of increasing the clamping effect, it undergoes a certain deformation and adaptation to the recess (35") of the connecting element (35).

9. Clamp connection according to claim 1 through 4, characterized in that for a cylindrical connecting element (25) with a pedicle screw (23) and with two recesses (25') for one structural element (22, 24) each, two annular clamp elements (28, 29) are introduced axially movable thereon, whereby the bracing means (26, 26') with the one clamp element (28), presses this with the upper structural element (22), which, for its part, comes to rest against the lower clamp element (29) and presses the latter against the lower structural element (24) resting on the connecting element (25).

10. Clamp connection according to one of the preceding claims, characterized in that the bracing means includes a threaded screw (16) fixed coaxially with the connecting element (15) as well as a nut (16') engaging on the respective clamp element (18).

11. Clamp connection according to one of the preceding claims, characterized in that the threaded screw (16) has, with respect to the connecting element (15, 25), a transverse groove associated with the structural element.

12. Clamp connection according to one of the preceding claims, characterized in that the position of the structural element (12) relative to the connecting element (15) is determined by the alignment of the recess for the structural element (12).

13. Clamp connection according to one of preceding claims, characterized in that the position of the structural element (22, 14) relative to the connecting element (25, 35, 45) is determined by a non-rotatable design of the inside surface of the clamp element (28, 39, 49) and the outside surface of the connecting element (25, 35, 45), preferably by a longitudinal tooth construction or by a noncircular cylindrical geometry of the connecting element and of the clamp element, preferably in a polygonal shape.

14. Clamp connection according to one of claims 1 through 13, characterized in that the connecting element (65) has at least on one of its sides a recess (65') bearing the structural element (12) and a coaxial threaded screw (66) therein as a bracing means, on which a clamp element (68) is arranged, which protrudes into the recess (65'), exercises on one side a clamping force acting parallel to the threaded screw (66) on a structural element (12) clamped between and, on the other side, rests with its external contact surface against an internal surface of the connecting element (65) parallel to the bracing direction and thus effects a bearing force perpendicular to the clamping force.

15. Clamp connection according to claim 14, characterized in that the recess (65') of the connecting element (65) is designed virtually cylindrically with an off-center slit for the

structural element (12), while the clamp element (68) has on the side turned away from the bracing surface a shape (65") corresponding to the recess (65').

16. Clamp connection according to claim 15, characterized in that the recess (65') and the shape (65") end in a radius.

17. Clamp connection according to claim 15, characterized in that the recess (65') and the shape (65") form an inclined plane.

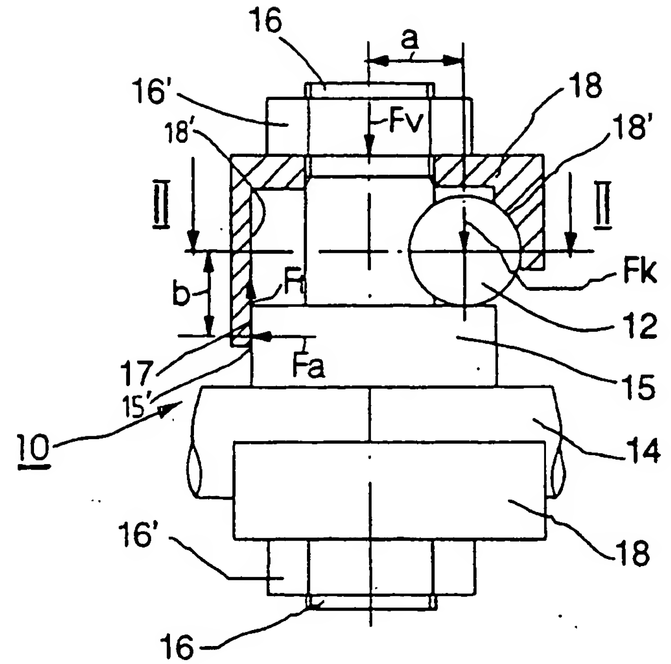


Fig.1

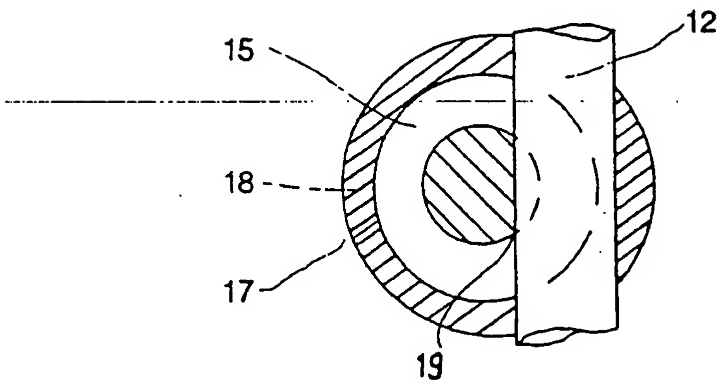


Fig.2

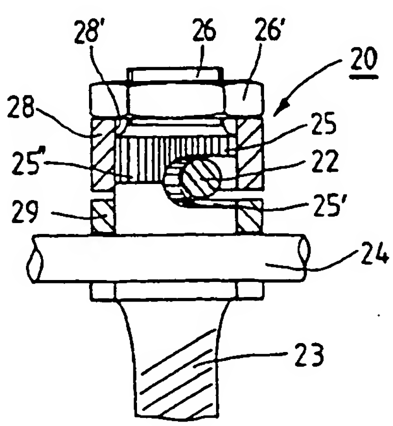


Fig.3

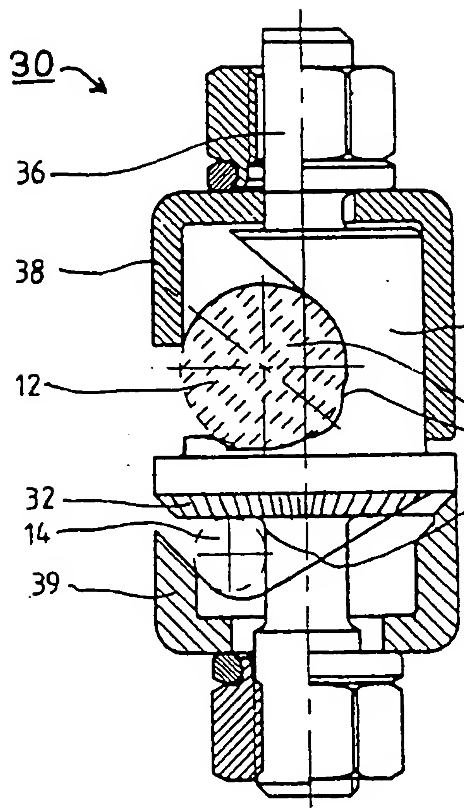


Fig.4

Fig.5

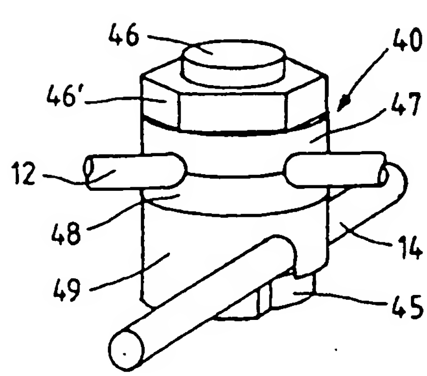
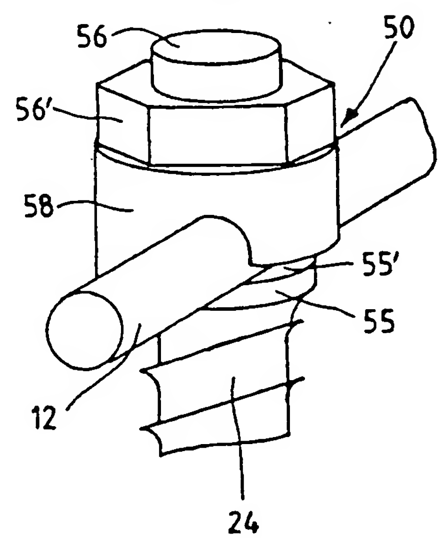


Fig.6



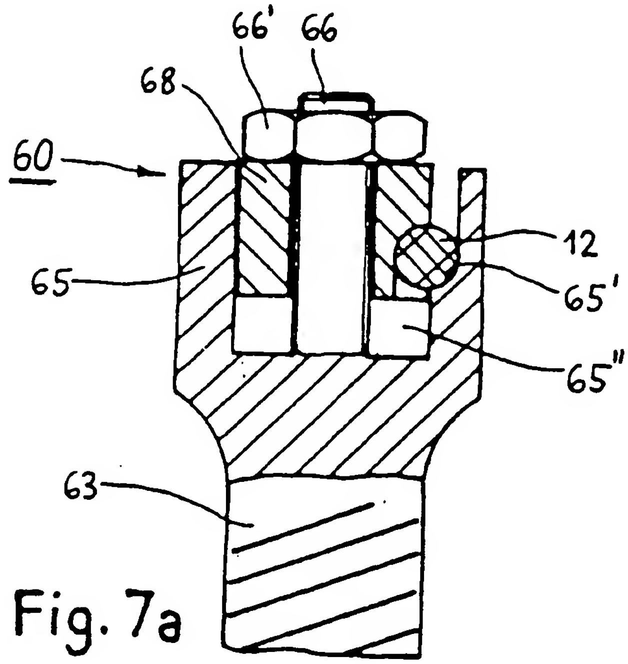


Fig. 7a

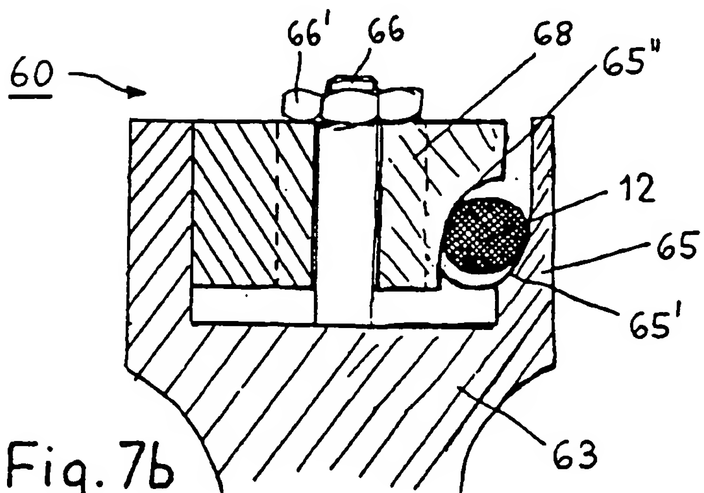


Fig. 7b